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Project ASTER: A Model Staff Development Program and Its Impact on Early Childhood Teachers' Self-Efficacy

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Introduction

Once again, a proliferation of reform recommendations has blitzed American education, resulting in systematic restructuring across the country. As schools transition through a plethora of changes in science education, it is critical to acknowledge the important roles that professional development and teacher beliefs play in this evolving process. In this paper, we describe a model of professional development for early childhood science teachers based on our experiences over the past two years with Project ASTER: Active Science Teaching Encourages Reform. In this project, we have identified seven elements that constitute a quality professional development program. These elements include (1) strong partnership between school districts and institutions of higher education, (2) unique collaboration between science educators and scientists, (3) three-phase training program designed around the school district's adopted course of study and national science standards, (4) integration of community resources, (5) partnership with preservice teachers, (6) development of teacher leaders, and (7) comprehensive program evaluation. The model of professional development implemented in this project is based upon the recommendations from Haney and Lumpe (1995) and Loucks-Horsley, Hewson, Love, and Stiles (1998) that mirror suggestions found in various national curriculum science standards. Moreover, our model emphasized enabling the teachers to become engaged with strategies that consist of ongoing processes rather than "one-shot" workshops. In addition, this study sought to explore the impact of the ASTER model of professional development on teacher self-efficacy and perceptions about science teaching.

The *National Science Education Standards* (*NSES*) (National Research Council [NRC], 1996) state that the professional development of science teachers should be accomplished by actively involving teachers in scientific investigations by examining both the content and process of science and by incorporating opportunities for reflection and collaboration. In addition, good science teacher development is characterized as "integrating knowledge of sciences, learning, pedagogy, and students" (p. 62), as "building understanding and ability for lifelong learning" (p. 68), and as experiencing a coherent and integrated inservice program. This can be a lofty goal considering educational researchers have also demonstrated that many elementary teachers do not teach science, and they lack a conceptual understanding of the content. Likewise, it has long been recognized that there are serious concerns

regarding elementary science teachers' attitudes, beliefs, and self-efficacy about science teaching. For example, the 1995 National Science Foundation (NSF) report, *1994 Indicators of Science and Mathematics Education*, details the fact that many elementary teachers lack sufficient science background to teach science effectively and that many science teachers are ill prepared to teach science (Wenner, 1993). Elementary teachers have long been known to possess negative attitudes about science teaching (Shrigley, 1974) and to lack confidence in their ability to teach science (Tilgner, 1990). General agreement exists that lack of such a background in science knowledge significantly contributes to hesitancy and possible inability to deliver effective science instruction in classroom settings. Since recent research studies indicate that the classroom teacher is the most important factor in improving student achievement in school (Sanders, 1998a, 1998b), we find that improvement in student learning begins with improved teacher education and ongoing professional development.

Teacher Beliefs and Self-Efficacy

The *NSES* indicate that teachers' actions are influenced by their perceptions of science and that "All teachers have implicit and explicit beliefs about science, learning, and teaching" (NRC, 1996, p. 28). Opportunities to examine these beliefs are essential so that teachers can be effective science instructors. An abundant body of research supports the idea that teachers are the critical change agents paving the way for educational reform and that teacher beliefs are precursors to change (Ajzen & Fishbein, 1980; Battista, 1994; Pajares, 1992). Much of the research on self-efficacy is based upon the social cognitive theory of Bandura (1977, 1981, 1986). He noted that beliefs are thought to be the best indicators of the decisions individuals make throughout their lives (Bandura, 1986). Furthermore, since teachers possess beliefs regarding their professional practices, and since these beliefs impact their actions, careful examination should be given to the role of teacher beliefs so that the problems and past failures in educational reform can be identified and remedied (Cuban, 1990).

Not surprisingly, the evaluation of teacher self-efficacy as indicators of teacher classroom behavior has been studied by a multitude of researchers in the field of science education (Brickhouse, 1994; Czerniak & Chiarelott, 1990; Czerniak & Shriver, 1994; Levitt, 2001; Lumpe, Haney & Czerniak, 2000; Lumpe, Czerniak, Haney & Beltyukova, 2004; Moseley, Reinke, & Bookout, 2003; Ramey-Gassert, Shroyer & Staver, 1996). Specifically, Czerniak and Shriver (1994) found that preservice teachers with high levels of self-efficacy implemented inquiry-based practices whereas those teachers with a lack of science content background possessed low levels of self-efficacy. Hence, Bandura's (1981) description of self-efficacy as a situation-specific construct can be applied to science teaching and may help to explain teachers' thought processes and behaviors related to science teaching. All these data taken together suggest that it is critical to examine the role of self-efficacy and the context of science teaching (Plourde, 2002) as such beliefs have the possibility of impacting the quality of teaching and student learning (Lumpe et al., 2000).

Background Information

Project ASTER was based on a previously funded National Science Foundation program entitled TAPESTRIES—Toledo Area Partners in Education-Support Teachers as Resources for Improving Elementary Science. TAPESTRIES was initiated in 1998 to develop a comprehensive school science program through sustained professional development of all K-6 teachers in two large, urban school districts.

Recently, TAPESTRIES has been nationally recognized for its success by receiving the Christa McAuliffe Award for Excellence in Teacher Professional Development from the American Association of State Colleges and Universities. Additionally, a recent study released by The Urban Affairs Center from the University of Toledo reveals the positive effects and impact of the TAPESTRIES program on student achievement (see the Urban Affairs Center website: uac.utoledo.edu/).

The successful experience afforded by the TAPESTRIES program served as a motivator for a cadre of science educators and scientists to continue their collaborative experiences and expand TAPESTRIES efforts to other Toledo area schools with similar needs in order to improve science teaching, learning, and achievement. Initiated in 2001, Project ASTER modeled several components from TAPESTRIES; however, it operated on a smaller scale and focused on the professional development of early childhood teachers (55 teachers so far) from a Toledo-area public school district and several smaller private schools. A novel component of Project ASTER was the integration in the classroom of community resources such as the Toledo Zoo and the Center of Science & Industry (COSI) in Toledo. Other unique components of Project ASTER included its connection to preservice teachers and the participation of first-year ASTER teachers as Teacher Leaders in the second year of the project and beyond.

Elements of the Project ASTER Model

Element 1: Strong Partnership Between School Districts and Institutions of Higher Education

Project ASTER is a science professional development project funded by the Ohio Board of Regents Improving Teaching Quality Program and is a collaborative effort between educators and scientists from Bowling Green State University (BGSU) and the University of Toledo (UT), The Central City Ministries of Toledo (CCMT), and Washington Local Schools (WLS). CCMT is an ethnically diverse district: "Our parish schools and neighbors are known for urban blight, crime, drugs, gang activity, and violence." In WLS, state science achievement scores are among the lowest in the Toledo area.

Since 1992, collaborative projects between institutions of higher education and private and public schools in the northwest Ohio area have made significant contributions toward assisting the comprehensive development of K-12 science programs. To date, these projects have resulted in new science courses of study, pedagogical practices that promote reform recommendations, and the development of inquiry-based integrated curricula.

Element 2: Unique Collaboration Between Science Educators and Scientists

Project ASTER is unique in that science educators collaborate with university scientists, forming teaching teams during the summer institute. The scientists help the science educators improve content knowledge, while science educators ensure that the pedagogy is consistent with state and national standards. This idea was based on data that suggest that when teachers work on investigations with scientists, they can develop increased interest in and understanding of scientific processes, gaining greater confidence in their ability to teach science using inquiry methods (Brewer & Manning, 1995; Caton, Brewer, & Manning, 1997). Historically, the faculty members from the Colleges of Arts and Sciences and Education from

BGSU and UT have a notable record of collaboration and dedication toward improving science education in the northwest Ohio area.

Element 3: Three-Phase Training Program Designed Around School District Course of Study

Phase I: Laying the Groundwork

In order to improve the pedagogical content knowledge and skills of the teachers, the first phase of Project ASTER engaged them in a series of professional development seminars (15 hours), which were conducted after school hours. The seminars focused on best practices in science and included topics on the integration of inquiry, cooperative learning, state and national science standards, learning cycle model, and constructivist teaching practices. At the completion of Phase I, the teachers felt well prepared to enter into the summer science teaching institute with a newfound excitement and a desire to learn more about effective science teaching and learning. This phase also established a positive atmosphere and developed a level of trust among the participants and the instructors. It also helped diminish fears about science teaching among this community of learners.

Phase II: Summer Institute

The second phase of Element 3 served as a core component in meeting the intended program goals. For example, it has been shown that focused time is critical for the teacher's development of skills and understanding because professional development programs rarely address the individual needs and concerns of staff or are not connected with new programs or practices that may be implemented at the school. Hence, every effort was made to align Project ASTER with the direct needs of the teachers in our partner schools. In particular, Phase II focused primarily on science content as participants engaged in an intense two-week summer institute at the university campus. Here, the teachers participated in sessions aligned with the districts' K-3 course of study and adopted curricula, which included the Full Option Science System (FOSS), a program developed at the Lawrence Hall of Science with NSF support and the Teaching Relevant Activities for Concepts and Skills (TRACS) science series by Kendall Hunt. These curricular materials contain ideas that model current reform trends such as hands-on/inquiry-based experiences based upon learning cycles and holistic student achievement. The summer institute consisted of six instructional hours per day, a three-hour morning session and a three-hour afternoon session. Each grade-level specific session followed a 5 E Learning Cycle Approach (Bybee, 1997) and focused on a specific area of the curriculum such as life science, physical science, or earth/space science using the district-adopted curricular materials. The teachers fully explored their science kits in a hands-on/minds-on fashion as a science educator and university scientist teaching team facilitated the sessions. Participants culminated their experience with the development and presentation of 5 E model unit plans unique to the needs of their students. The afternoon session of the second week of the summer institute focused on utilizing community resources as means to enhance the science curriculum (further described under Element 4).

Phase III: Follow Up & Dissemination

Phase III provided five follow-up seminars that focused on the implementation of units developed by the teachers during the summer. At this point, the teachers

had the opportunity to "pilot test" what they created and experienced during the summer. This was also a time for discourse among the teachers regarding successes and/or challenges related to their science teaching. An additional component to this phase was the dissemination of ASTER learning experiences to other teachers in their school districts and across the state of Ohio. This was accomplished in a variety of ways. For example, some teachers reached out to the community and conducted "Family Science Nights" to circulate information to parents and community members. Other teachers presented their 5 E units and shared their learning experiences with their peers at the annual conference for the Science Education Council of Ohio, and other teachers chose to lead workshops at regional science professional development symposia. Notably, Phase III has served as an empowering leadership experience for ASTER teachers and has helped to stimulate interest from those teachers who have not yet participated in the program, helping to form the next cohort of ASTER participants.

Element 4: Integration of Community Resources

As previously mentioned, several community agencies were visited during the second week of the summer institute. The community resources included the Toledo Zoo; the Planetarium of BGSU; UT's Stranahan Arboretum and Science and Mathematics Technology Education Center (SciMaTEC); and COSI Toledo, an interactive science museum. These community resources hosted the Project ASTER participants and provided practical opportunities for them to explore how to integrate community resources into their curriculum.

Element 5: Partnership with Preservice Teachers

Another novel component of Project ASTER was its connection to preservice teachers. Specifically, early childhood education (preK-3) teachers from BGSU have had the opportunity to conduct their field-based teaching experiences (methods and student teaching) with teachers who participated in the program. This interaction enhanced the student teachers' science experiences since the early childhood education program requires the least amount of science content compared to other teaching certificates. The students were able to work with teachers who embraced inquiry-based science teaching and to see direct applications of their university course preparation to authentic classroom settings. Also, the field placement of preservice teachers in ASTER teacher classrooms provided continued support for the ASTER teachers as the preservice teachers were well-versed with the school district's curriculum materials, the *NSES*, and the Ohio standards for science education.

Element 6: Development of Teacher Leaders

Another unique ASTER component dealt with teachers from ASTER's first cohort. Specifically, five teacher leaders served as consultants and leaders during the ASTER II summer institute where they joined the scientist-science educator teams. These teacher leaders were able to share their own learning episodes, assessments, and experiences with the newly implemented, inquiry-based science curriculum with ASTER II teachers. This component continued to build and sustain the foundation developed with the first ASTER cohort and helped to maintain the intense focus on science education.

Element 7: Comprehensive Program Evaluation

As part of the program evaluation, several types of data from ASTER have been collected, analyzed, and reported by an external evaluator. The sources of data used to analyze the effect of ASTER on teacher attitude and self-efficacy levels were classroom observations, professional development observations, teacher interviews, reflective analyses, and teacher surveys. The data collection is consistent with recommendations from the National Staff Development Council's (2001) Standards for Staff Development for incorporating the use of multiple sources of information to guide improvement and demonstrate the program's impact (Evaluation Standard). Furthermore, No Child Left Behind, Title II, Part A, states that professional development programs will be "regularly evaluated for their impact on increased teacher effectiveness and improved student achievement, with the finds of the evaluation used to improve the quality of professional development."

Research Questions

To evaluate the impact of Project ASTER on teacher self-efficacy, the following research question was examined: How did the ASTER model of professional development impact teachers' self-efficacy and perceptions about science teaching?

Methodology

The Science Teaching Efficacy Belief Instrument A, STEBI-A (Riggs & Enochs, 1990), was used to measure science-teaching efficacy through a pretest/posttest research design. Riggs and Enochs state, "The STEBI is a valid and reliable tool for studying elementary teachers' beliefs toward science teaching and learning" (p. 633). This instrument contains 25 Likert-style items that comprise two subconstructs of teacher beliefs based upon Bandura's (1986) cognitive dimensions labeled "personal self efficacy" and "outcome expectancy." On the one hand, personal self-efficacy is a measure of the degree to which a science teacher believes they can succeed in teaching science. On the other hand, outcome expectancy is the measure of the degree to which a science teacher expects their students to succeed as a result of their teaching. The STEBI-A was administered to all of the Project ASTER teachers at the beginning of Phase I and at the end of Phase III. The professional development experience for each year of the project (Year 1: 2002-2003 and Year 2: 2003-2004). The participants were asked to indicate their level of agreement with each of the 25 survey items. Finally, a qualitative review of the 55 participants final reflections was used to cross-reference the results of the STEBI-A. To identify themes, a review of the final reflections was conducted by two independent reviewers—one science education faculty member and one science education graduate student. Common themes were identified and defined. Themes were coded, and those teacher quotes that best exemplified the final theme were identified. Themes that showed a high level of inner-rater reliability were included in this report.

Participants

The sample for this study included 55 early childhood inservice teachers from public and private schools in northwest Ohio, who participated in Project ASTER's three-phase professional development program. There were 27 teachers in Year 1 of the project and 28 teachers in Year 2.

Results

Year 1 STEBI-A FINDINGS

Two paired *t*-tests were run on 27 subjects comparing pretest to posttest scores on efficacy and outcome constructs. Results of the paired *t*-tests for the self-efficacy subscale yielded a *t*-value of 7.92 (p = < .0001). The mean gain score between the pre- and posttest score was 11.72. Results of the paired *t*-test for the outcome expectancy subscale yielded a *t*-value of 2.11 (p = .0443). The mean gain score between the pre- and posttest score was 1.26.

Year 2 STEBI-A FINDINGS

Significant findings were also present during Year 2 on tests run on 28 subjects comparing pre- to posttest scores. Results of the paired *t*-tests for the self-efficacy subscale yielded a *t*-value of 9.54 (p = <.0001). The mean gain score between the pre- and posttest score was 10.71. The results of the paired *t*-test for the outcome expectancy subscale yielded a *t*-value of 2.94 (p = .0067). The mean gain score between the pre- and posttest score was 3.14.

Table 1. Year 1 Paired *T*-Test Comparison

Measure	Mean Difference	SD	*t*-Value	*p* Value
Self-Efficacy	11.72	7.70	7.92	.0001
Outcome Expectancy	1.26	3.10	2.11	.0443
n = 27				

Table 2. Year 2 Paired *T*-Test Comparison

Measure	Mean Difference	SD	*t*-Value	*p* Value
Self-Efficacy	10.71	5.94	9.54	.0001
Outcome Expectancy	3.14	5.66	2.94	.0067
n = 28				

Final reflections from Project ASTER I and II teachers serve as additional data to cross reference the STEBI-A data. Those themes relevant to this study include "Increased Confidence Level" and "Renewed Enthusiasm for Science Teaching." The first theme relates to the teachers' perceived self-assurance in their science teaching skills, whereas the second theme reflects on a newfound excitement and positive anticipation for science teaching. The following teacher quotes support each of the themes:

Theme 1: Increased Confidence Level

Project ASTER has made me a more self-assured and well-prepared science teacher. I have a deeper understanding of the subject matter. I am now comfortable adding meaningful extensions that will further the students' understanding of science. Grade 1 teacher

My goal of becoming more confident in my science teaching is becoming a reality. I know that I have already become more knowledgeable of science content and process. I will be prepared to enter my classroom in the fall with a great science attitude because I am no longer afraid of science. Grade 3 teacher

I am confident that my lessons will be "whole" this year with the materials and community resources that I now know are available to help me. Grade K teacher

Coming into this project, I had some familiarity with the science curriculum. I now have a far better understanding and comprehension of each lesson as well as the benchmark standards they address. This will also help me tremendously in adapting and adjusting for children with special needs. Grade 2 teacher

Theme 2: Renewed Enthusiasm for Science Teaching

Next year, I plan to teach more science. This year, I only taught science twice a week. Now, for next year, I want to teach science every day. ASTER is a powerful experience, and it really did help me to love science. Grade 3 teacher

I will return to school in the fall with a different outlook on what each science lesson should accomplish. I only hope that I can be an inspiration and model for other teachers. Grade 1 teacher

I am actually excited to use what we have learned and can't wait to see for myself, through my students, what I know I learned by going through the lessons. Grade 2 teacher

I am delighted with all of the information I have gained from this experience. I don't know if I have ever been this excited about science before. Grade K teacher

Discussion

Results from this study indicate that participation in Project ASTER I and II had a positive impact on the teachers' self-efficacy and outcome expectancy as their scores on both of these constructs significantly increased after participation in the projects. These data confirm that a sustained professional development, such as the one described in the ASTER model, may influence these types of beliefs. Likewise, a review of final reflections supports the improvement of teacher self-efficacy, confidence, and renewed enthusiasm for science teaching. This may be best exemplified by the teacher's comment, "Now, for next year, I want to teach science every day."

Findings of improved teacher self-efficacy beliefs are consistent with those reported by Lumpe et al. (2004). One component of their study investigated the

impact of a professional development program, TAPESTRIES, on teachers' beliefs using the STEBI-A instrument and found that after participation in the program, the teachers displayed significantly higher context and self-efficacy beliefs. Unlike the findings reported in this study, however, Lumpe et al. (2004) did not find significant gains in outcome expectancy. As described above, the ASTER model was inspired by TAPESTRIES. In fact, several components of TAPESTRIES were applied to ASTER. Even so, differences in outcome expectancy may be due to many factors. For instance, TAPESTRIES was a much larger-scaled program, reaching over 1,000 K-6 teachers in a primarily large urban school setting, whereas ASTER's program operated on smaller scale, focusing on only 55 early childhood teachers in schools with different demographics and unique administrative support. Follow-up interviews with teachers from each program may help explain these differences.

The design components of the ASTER model were purposefully selected and planned to help improve teacher self-efficacy. The program goals and project activities examined and applied research on effective professional development and self-efficacy beliefs from an assortment of studies and reports (Fullan, 1982; Haney & Lumpe, 1995; Loucks-Horsley et al., 1998; Lumpe et al., 2000). For example, Fullan (1982) warns us that most professional development programs fail where (1) there is a profound lack of any conceptual basis in the planning and implementation of the programs, (2) one-shot workshops rather than ongoing experiences are implemented, (3) topics are frequently selected by people other than those for whom the professional development is intended, (4) follow-up support for ideas and practices introduced in the programs does not occur, and (5) the programs rarely address the individual needs and concerns of staff. These warnings were carefully considered and addressed during the development and implementation of the ASTER model.

In addition, strategies that gave the teachers opportunities to develop and construct understanding from their own experiences were tackled in Project ASTER. An example includes conducting investigations that enabled teachers to make meaning out of science activities. Collecting data, organizing information, and defending explanations engaged the teachers engaged in hands-on/minds-on experiences in the same way that they were expected to work with their own students. An important element in making this work was the involvement of qualified scientists and science educators who had used these techniques with their own students. Also, a commitment to long-term training was a crucial component. The ongoing ASTER experience spanned three semesters. These experiences and focused time enabled the teachers to see science teaching as less a matter of knowledge transfer and more of an activity and process.

Other critical strategies implemented during ASTER included curriculum implementation and collaborative work (Loucks-Horsley et al., 1998). Through the use of new curricula with students and peers, teachers implemented new lessons in the classroom and came back to collaborate with their peers and project staff to address curricular modifications, concerns, adaptations, and successes. The collaborative focus and feedback mechanism of this professional development experience are critical components that should not be ignored and may warrant further investigation. Hence, ample time was given for the teachers to reflect and implement their new strategies with feedback provided on a regular basis.

Finally, establishing partnerships with scientists, businesses, community resources, or universities provided another means for collaborative work. Working with practicing scientists, with the focus on improved teacher content knowledge and access to resources, served as a vehicle to strengthen the professional development (Caton et al., 1997; Stein, 2001). The ASTER experience was designed

so that teachers would no longer see themselves as the only source of knowledge in the classroom; rather, they would work to become facilitators and help students learn from experiences.

Conclusion and Implications

The following implications can be drawn from this study:

- Teachers should be given opportunities to collaborate with others implementing the same curriculum.
- Professional development opportunities should engage teachers in an immersion into inquiry process, which is directly focused on teacher needs.
- Teacher beliefs may increase when professional development programs are made up of ongoing processes rather than one-shot workshops and involve the collaboration of peers, science educators, scientists, and community agencies.
- A well-designed model of professional development may impact and improve teacher self-efficacy beliefs.

In summary, the overarching goal of Project ASTER was to provide a sustained program of professional development and support with a lasting effect on students, teachers, and administrators. Focusing on science content and pedagogy, it was modeled after state and national science education standards and designed to help prepare K-3 teachers to become confident and effective teachers of inquiry-based physical, life, and earth/space science. We have identified seven specific elements that are critical to the overall structure of the model. These elements include (1) strong partnerships between school districts and institutions of higher education, (2) unique collaboration between science educators and scientists, (3) a three-phase training program designed around the school districts' adopted course of study and national science standards, (4) integration of community resources, (5) partnership with preservice teachers, (6) development of teacher leaders, and (7) comprehensive program evaluation. Careful design and implementation of these components have resulted in a successful professional development program for K-3 science teachers that impacted their self-efficacy, confidence, and enthusiasm for science teaching. Many of the teachers began their ASTER experience with poor self-confidence and a lack of enthusiasm about their ability to teach science effectively, and they left the ASTER experience with a newfound confidence and eagerness, which spills over into their classrooms and schools as shown in the teachers' quotes. Lastly, and very importantly, the Project ASTER professional development program has challenged the teachers to assume new roles, achieve higher standards, and accept new responsibilities.

Future Research

We are now in the process of examining the influence of Project ASTER on student achievement. In order to appropriately evaluate ASTER's effect on student achievement such as those reported in the TAPETRIES findings, more longitudinal data are needed from additional ASTER teachers and students. We are also adding a new component to Project ASTER wherein we will examine the cognitive impact of integrating community resources on student achievement. Project ASTER III is

currently in progress. Since the onset of ASTER, the achievement scores on both the 4th and 6th grade Ohio Science Proficiently Tests have increased in Washington Local Schools. We are aware that this increase may be due to many variables; however, it is clear that Project ASTER is positively impacting teacher self-efficacy, and it is likely that there is improvement in the quality of science teaching and learning in the schools that participated in the project.

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